Appl. No. 09/592,950

REMARKS / ARGUMENTS

In response to the first restriction requirement, applicants confirm the election of claims 4-12 for examination.

In response to the drawing objections, an amended Figure 1 is enclosed, including the reference numerals 18, 27, together with a set of formal drawings including this amendment. A description of Figure 3c has been added on page 8.

The amendment to claims introduce no new matter to the application, the amendments being largely editorial and clarifying the nature of the two catalysts and ensuring that there are proper antecedents.

Claim 4 has been amended as required by the Examiner and is submitted to be now fully in compliance with 35 USC 112. Claim 4 has been revised to provide the necessary antecedent identified by the Examiner, to clarify the use of the term "catalyst", and otherwise to provide clear antecedents. Further, as claim 7 refers to claim 4, for consistency, the outlet of the catalytic reactor has been amended to be for remaining gas that has been heated and humidified, instead of for heated and humidified fuel.

Claim 7 has been amended to correct a minor typographical error and also for clarity. It is apparent that the original wording was intended to mean as amended and hence introduces no new matter. Following the amendment to claim 4, the word "remaining" has been introduced in line 6.

Corresponding to the amendments to the claims, the last two paragraphs on page 10 are being amended to insert reference to "the remaining air" and "remaining hydrogen". It will be understood that reference to "remaining" merely is for clarity and that no new matter has been added. The invention has always been clearly described as having a reactor in which an oxidant and a fuel, e.g. hydrogen, are reacted, to generate heat and moisture. Where there is an excess of one of the oxidant and the fuel, then this excess will be "remaining" gas that is, necessarily, heated and humidified.

Claim 11 has been amended for clarity. As claim 11 refers to claim 4, the original claim 11 mistakenly stated that catalytic reactor is disposed in main air supply line. It is actually the secondary catalytic reactor that is disposed in main air supply line to provide humidified air, with the other catalytic reactor providing humidified fuel. Such amendment is supported on Page 11, line 14-17. It will be understood that this merely amounts to changing the designation of the two reactors as first and second, without changing the structure claimed in claim 11. Additionally, again to ensure proper antecedents, a reference to the main fuel supply line has been inserted at the beginning of claim 11.

The Examiner rejected claims 4-7 and 9-12 as being unpatentable under 35 U.S.C 103(a) over Micheli et al 5541014. These rejections are respectfully traversed.

The Examiner recited the abstract of the Micheli patent and argued that in light of the Micheli patent it is obvious for one skilled in the art to use a catalytic burner to generate heated and humidified fuel, as is claimed by the instant application. This analysis is respectfully traversed.

Micheli et al patent relates to solid oxide fuel cells (SOFC) and molten carbonate fuel cells (MCFC). These fuel cells operate at high temperatures. The Micheli patent combines turbines cycles with these fuel cell cycles, and in order to optimize cycle efficiency, it is desired to ensure the turbines operate at their optimum temperature range. Micheli et al utilize combustors to burn excess fuel to raise the temperature of gas stream fed to the turbines to a desired temperature at which turbines will operate at high efficiency. Considering the operating temperatures of SOFC and MCFC and turbines, the combustors used in this patent also operate at high temperature, for example above 1000°F, as can be seen from Col 2, line 42 and further from Col 3, lines 51-55, and at column 6, line 20, it is suggested that the temperature at the outlet of combustor 47 could be in the range 1800° to 2300°F. It can be understood by those skilled in the art that the combustors (41, 47) operating at such temperatures are <u>not</u> catalytic reactors. Catalytic reactors use a catalyst to facilitate oxidation reaction of fuel and generate water, and operate in temperature ranges considerably lower than that of the combustors disclosed in the Micheli patent. Moreover, catalytic reactors involve no flames during reaction. In contrast, direct combustion occurs in the combustors disclosed in Micheli patent and it can be understood that flames are involved. Hence, the catalytic reactors and combustors in the Micheli patent are quite different.

It can also be understood by those skilled in art that for SOFC and MCFC, humidification of the fuel is not a concern. That is one of the reasons for combustors being disposed such that they combust excess fuel in a fuel <u>exhaust</u> stream. Although the Micheli patent disclose using conduit 73 to provide steam to the anode of SOFC, it is noted that the steam is used for reforming fuel to generate hydrogen internally of the fuel cell, as can be seen from Col 2, lines 12-21. It is <u>not</u> used for humidification of fuel, since humidification of the fuel has no

meaning in the context of SOFC or MCFC systems. Note also column 7, lines 35-39, where it is made clear that the supply of steam, to both fuel cells 5 and 7, is for "reforming the CH_4 to H_2". The Examiner suggested that the "conduit 73...provides a heated and humidified fuel back to the fuel cell". This is not understood. Firstly, the conduit 73 is not connected to the high pressure combustor 47 as clearly shown in the drawings but rather is a steam conduit, with steam being generated by entirely conventional heat transfer processes.

It is noted that the output of the high pressure combustor 47 is in fact a conduit 53. This is connected to a turbine 9, where energy is extracted from the hot, pressurized gas flow. The gas then flows to a low pressure combustor 41, together with an exhaust from the anode of the MCFC 7, flowing through conduit 57 (see the paragraph at column 6, lines 35-57). Unreacted hydrogen and CO from the MCFC anode exhaust is combusted in the low pressure combustor 41, the resultant hot gas flow passes into a heat exchanger 39. It is suggested that the temperature of the gas flow leaving the combustor 41 is in the range 1100° to 1400°F, and that this gas flow, leaving the heat exchanger 39 then has a temperature in the range 1000-1150°F and is passed into the cathode of the MCFC.

As explained in the paragraph bridging columns 6 and 7, one of the reasons to use the heated gas flow is to ensure "the liquifaction of the carbonate electrolyte", which is quite different from the "membrane" of the present invention. Moreover, in this whole discussion of the gas flow through the various combustors to the MCFC 7, there is not mention of the presence or significance of moisture, since it is simply not necessary to have moisture present for proper operation of this type of fuel cell.

The Examiner, earlier, had argued that the SOFC 5 provides "two porous electrodes bonded to a solid oxide ceramic membrane disposed between them". Rather, at column 4, lines 39-41, the SOFC 5 is described as having "two porous electrode 11 and 13 bonded to a solid oxide ceramic electrolyte 15 disposed between them to form a selective-permeable barrier".

It is submitted that a solid oxide electrolyte is, in no sense, a "membrane". For example, a membrane is often defined as a "thin, pliable and often porous sheet". While Applicants do not wish to be restricted to this precise definition, it is noted that the solid oxide electrolyte of an SOFC fuel cell falls far short of any definition of a membrane.

As mentioned above, in Micheli patent, the combustors (41, 47) are provided for raising the gas stream fed to the turbines to a desired temperature. The combustors are not used to generate moisture in the gas stream in order to humidify the gas stream. The Micheli patent repeatedly mentions that by changing the amount of fuel supplied to the SOFC, the temperature of the gas supplied to the turbines can be adjusted. Nowhere does Micheli mention the content of moisture of such gas stream. Hence, Micheli et al are only concerned with the temperature of the gas stream. It in no way suggested humidifying incoming reactant streams for a fuel cell.

From Col 6, lines 26-33, the Micheli patent discloses that it may be required to add <u>excess</u> fuel, thus providing <u>excess</u> fuel to the higher pressure combustor. It is clear that this is to alter the temperature of the gas stream supplied to the turbines. It is not used to generate a humidified fuel stream in Micheli patent, as this is definitely not desired in Micheli patent.

In view of the foregoing, it is submitted that it is not obvious to one skilled in the art to make the fuel cell system as claimed in claim 4 in light of the Micheli patent and hence claim 4 is allowable. It is also submitted that all of claims 5-12 are allowable as being dependent from an allowable independent claim 4, and to introducing further patentable features.

More particularly, the Examiner's argument against claim 7 that the high pressure combustor is connected to main fuel inlet through conduit 73 and to gas channel of a second fuel cell through conduit 59 is respectfully traversed. Although conduits 73 and 59 are respectively connected to anode and cathode of first and second fuel cells, they are in no way in direct fluid communication with the higher pressure combustor, as explained above. Moreover, the conduits 73 and 59 are respectively connected to two different fuel cells, having quite different characteristics. This is quite different from what is claimed in claim 7 and it would be in no way obvious to employ the arrangement of Micheli patent to the present invention. Again, as mentioned above, the purpose of providing excess fuel in the Micheli patent is quite different from that of the instant application. Further, the Micheli patent did not disclose selectively providing humidified fuel or oxidant to the fuel cell and nowhere did it make such suggestion.

For amended claim 11, the Micheli patent nowhere teaches or suggests providing two catalytic reactors, each specifically used to humidify one reactant stream of a fuel cell. Again, the Micheli patent is concerned with heating a gas stream supplied to a turbine to a desired temperature. It in no way suggests humidifying incoming reactant streams for a fuel cell.

With respect to claims 6 and 12, the Examiner again analyzes the Micheli et al. disclosure, and notes that this discloses a fuel cell system that may provide a

thermodynamically optimized system, that can enhance fuel cycle efficiency by adding all of the heat energy obtained from unreacted and reacted stream effluents to the fuel cell anode and cathode. Again, the sole reason for doing this and the sole benefit, in the context of the SOFC and MCFC fuel cells, is to provide heat. The issue of moisture is simply not a factor.

With respect to the specific reactor shape, the Examiner made the unsupported allegation that Micheli et al. "inherently disclosed tubular combustors", on the surprising ground that these combustors are in fluid communication with conduits and since these conduits are either pipes or tubes, it would have been obvious to make the combustor having a similar configuration. Firstly, while it is conceded that circular tubes and conduits are well known and widely used, Micheli et al. is silent on the exact configuration of any of the elements in the system. More specifically, in the present invention, as detailed in the specification, it is essential to ensure that the full reaction occurs, and that the exhaust stream from the reactor does not contain one reactant with trace amounts of the other reactant; in a fuel cell, this could be potentially dangerous. This issue is nowhere addressed in Micheli et al., since it is not a factor with the different fuel cells used therein.

With respect to claim 8, the Examiner further relied upon the disclosure in Edlund et al. No novelty is alleged for individual valve components. Nonetheless, the invention in Edlund et al. is entirely different from the present invention. More significantly, Edlund et al. is concerned with an entirely different type of fuel cell from Micheli et al., and accordingly it is submitted that there is no reason or basis in this art for the modification proposed by the Examiner.

Accordingly, it is submitted that all the claims, as amended, are allowable, and early review and allowance are requested.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned **"<u>V rsion with markings to show changes made.</u>"**

Respectfully submitted,

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By ____________________
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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the specification:

Please amend the paragraph on page 8, at lines 16-17, as follows:

Figures 3a, ~~and~~ 3b and 3c are, respectively, perspective, ~~and~~ side and sectional views of a tubular reactor in accordance with the present invention;

Please amend the last two paragraphs on page 10, at lines 16-32, as follows:

To generate a flow of heated and humidified air, excess air is delivered by the pump 82, relative to the hydrogen flow through the line 74. In the tubular reactor 50, the oxygen reacts with the hydrogen to generate heat and moisture. This results in the remaining air being ~~a~~ heated and moistened ~~air flow~~and exiting through the outlet 56. Then, the valve 88 is maintained closed and the valve 89 is opened, so that the heated and moistened airflow passes through the main air supply line 66, to be entrained into the air flow passing to the fuel cell stack 62.

Correspondingly, to generate a heated hydrogen flow, the valve 88 is opened and the valve 89 closed. Then, excess hydrogen is supplied through the line 74, as compared to air supplied through the main fuel line 82. The flow is dead ended and is only exhausted during purging when the exhaust solenoid is open. However, the flow can be controlled using control valves when not operated in dead-ended mode. In the tubular reactor 50, the oxygen in the air reacts

with some of the hydrogen to generate heat and moisture. The flow of remaining hydrogen, with residual nitrogen, together with heat and moisture, then exits from the outlet 56. This flow of heated and humidified nitrogen and hydrogen gas passes through valve 88 into the main fuel line 72.

In the claims:

4. A fuel cell system, comprising:

at least one fuel cell, each fuel cell comprising:

a main fuel inlet for a fuel;

an anode having an anode catalyst associated therewith for producing cations from the fuel;

a fuel manifold, connected between the main fuel inlet and the anode, for distributing the fuel to the anode;

an oxidant inlet means for supplying an oxidant;

a cathode having a cathode catalyst associated therewith and connected to the oxidant inlet means, for producing anions from the oxidant, said anions reacting with said cations to form water on said cathode;

an ion exchange membrane deposed between said anode and said cathode, said membrane facilitating migration of cations from said anode to said cathode, while isolating the fuel and the oxidant from one another; and

a catalytic reactor having a first inlet for the fuel and a second inlet for ~~an~~ the oxidant, and an outlet for remaining gas that has been heated and humidified ~~fuel~~, the catalytic reactor being connected to the main fuel inlet, whereby, in use, with the fuel and the oxidant supplied to the catalytic reactor and the fuel being supplied in excess of the stoichiometric amount, the remaining, heated and humidified gas comprises heated and humidified fuel and is supplied from the catalytic reactor to the main fuel inlet.

6. A fuel cell system as claimed in claim 4 or 5, wherein the catalytic reactor is generally tubular.

7. A fuel cell system as claimed in claim 5, wherein the outlet of the catalytic reactor is connected by a first control valve to the main fuel inlet of the fuel cell stack and by a second control valve to the oxidant inlet means whereby, in use, the outlet of the catalytic reactor can be selectively connected to one of the main fuel inlet and the oxidant inlet means, with supply of the oxidant ~~as~~ and the fuel to the catalytic reactor adjusted so that the remaining, heated and humidified gas at the outlet of the catalytic reactor includes an excess of gas corresponding to said one of the main fuel inlet and the oxidant inlet means.

11. A fuel cell system as claimed in claim 10, wherein the catalytic reactor is provided in the main ~~air~~ fuel supply line, and wherein a second catalytic reactor is provided in the ~~fuel~~ main air supply line and a secondary ~~air~~ fuel supply line connects the main ~~air~~ fuel supply line to the secondary catalytic reactor, for a supply of ~~air~~ fuel in an amount less than the stoichiometric amount required for combustion ~~of fuel~~with air, whereby, the secondary catalytic reactor generates heated and humidified ~~fuel~~air.

12. A fuel cell system as claimed in claim 11, wherein each of the first and second catalytic reactors is generally tubular.

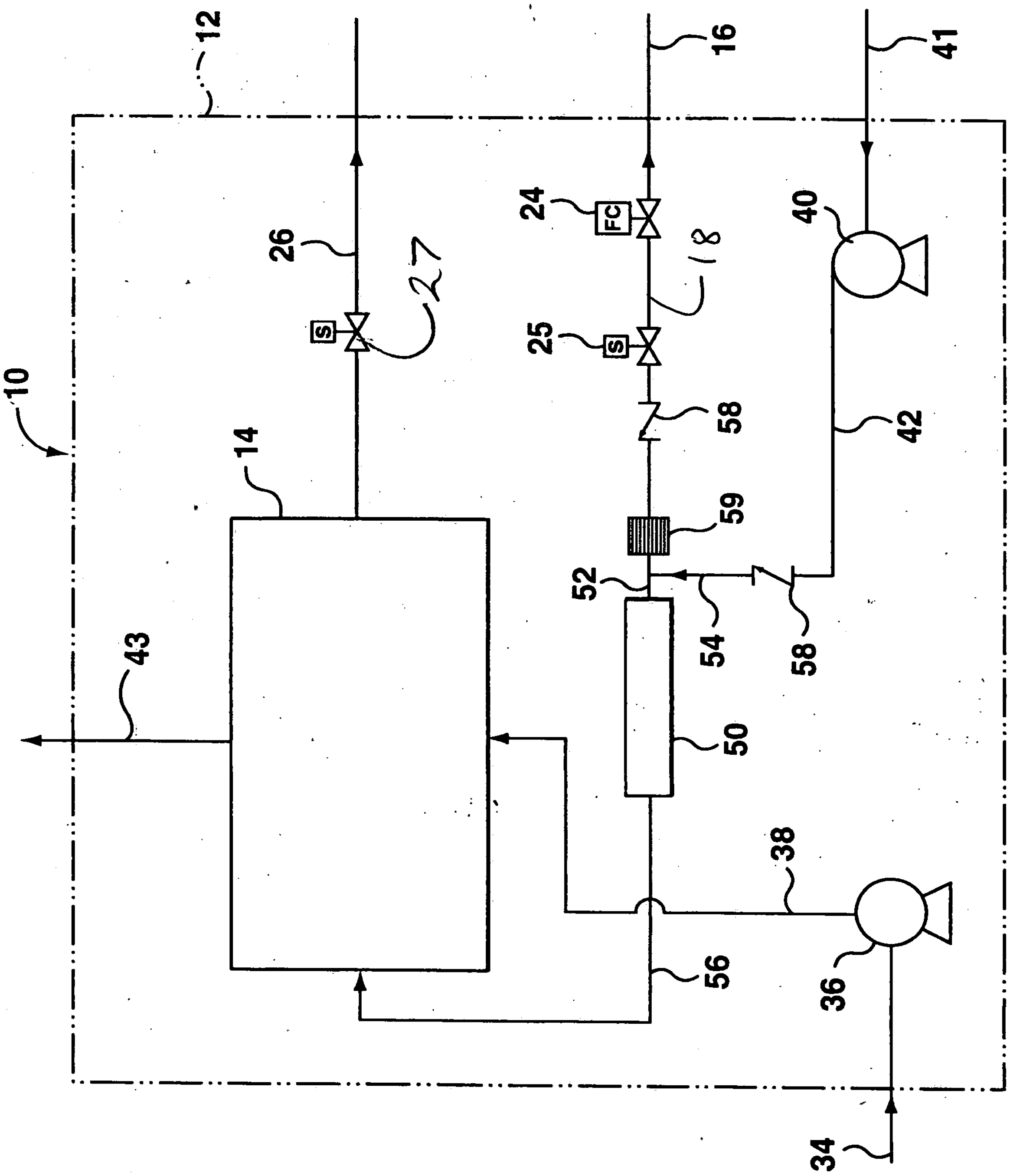

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FIG. 1